

# JOINT TRANSPORTATION RESEARCH PROGRAM

**Principal Investigator:** Shuo Li, Indiana Department of Transportation, sli@indot.in.gov, 765.463.1521

**Program Office:** jtrp@purdue.edu, 765.494.6508, www.purdue.edu/jtrp

**Sponsor:** Indiana Department of Transportation, 765.463.1521

SPR-3088

2012

## Evaluation of Pavement Surface Friction Treatments

### Introduction

The implementation of a pavement preservation program involves a learning curve with not only a determination to succeed, but also the courage to fail. Successful implementation of pavement preservation program requires knowledge of the performance of pavement preservation surface treatments over time, which is critical to the development of performance models for pavement management analysis. Additionally, preservation surface treatments, such as chip seal, fog seal, microsurfacing, and 4.75-mm thin or ultrathin overlay, can not only repair certain pavement surface defects, but also change the surface characteristics of pavement and therefore affect pavement surface friction performance. Nevertheless, such information is currently not available but is essential for the Indiana Department of Transportation (INDOT) to evaluate the effectiveness of pavement preservation surface treatments. As a concentrated effort, this study focused on the long-term friction performance of preservation surface treatments, particularly those have been widely used and those have seen increasing use by INDOT.

Based on the selected field pavement test sections, this study aimed to evaluate the surface characteristics, particularly the long-term friction performance for the surface treatments, such as chip seal, fog-chip, fog seal, rejuvenating seal, microsurfacing, ultrathin bonded wearing course (UBWC), 4.75-mm hot mix asphalt (HMA) thin overlay (UTO), and profile milling (or diamond grinding). The test sections for each type of surface treatment covered a wide range of traffic volume from light to high. The service life for the selected test sections varied from 6 months to 60 months. Friction testing was mainly conducted using ASTM E 274 locked wheel trailer. Surface texture testing was conducted using either the ASTM E 2157 circular track meter (CTM) or a laser scanner. Pavement roughness and noise tests were also conducted to address the smoothness and noise issues, particularly on microsurfacing. Detailed analysis was provided to evaluate the friction performance of 4.75-mm HMA thin overlays. It is believed that the test results and findings drawn from this study not only provides timely information for INDOT to improve its pavement preservation program, but also provides the original information for the potential readers to better utilize preservation surface treatments.

### Findings

#### Chip Seal and Fog-Chip Seal

On the newly chip sealed surfaces, surface friction numbers varied between 50 and 70. The greater the friction number on the old pavement, the greater the friction number on the new chip sealed surface. The surface friction decreased after opening to traffic. The greatest friction decrease occurred after 12 months in service. When the chip seals reached the age of about 30 months, the surface friction started to decrease continuously over time. It took 12 months for chip seals to form a stable mosaic. Successful chip seal

produced a friction number between 44 and 52 after 12 months in service. Failure was observed in two chip seal sections, which experienced dramatic decrease in friction at the age of 12 months and the resulting friction number was less than 30, commonly around 20.

Applying a fog seal on top of a chip seal resulted in an immediate, temporary decrease in friction by 20%-33%. The surface friction increased due to the material wearing off the tops of the chips tended to reach the maximum value after 6 months or more in service. This indicates that a fog-chip seal may form a stable mosaic faster than a standard chip seal. The surface friction in the fog-chip seals demonstrated a tendency to decrease over time after 12 months in service. The average friction number in the fog-chip seals at the age of 12 months was almost the same as that in chip seals at the age of 12 months. Failure was observed in one fog-chip seal section that demonstrated a friction number of about 20 after 12 months of service. It appears that a fog-chip seal may not necessarily perform as well as a standard chip seal in terms of surface friction.

For new chip seal, the friction number produced by crushed stone was 16.7% greater than that by crushed gravel. After 12 months in services, the difference in friction dropped to 7.0%. If this trend remains in the long term, it is very promising for future use of crushed gravels in chip seals. However, the use of uncrushed aggregate could result in a friction reduction.

Chip seals can be successful even on high traffic volume roads. It seems that truck traffic affected the performance of a chip seal more significantly than AADT. The failed chip seals commonly demonstrated poor surface friction and could easily be identified from the visual appearance, such as insufficient aggregate chips, binder-rich surface or both. The contributing factors to the failures in the test sections were not readily apparent. However, it appears that care should be exercised when applying chip seal to a pavement when its overall condition level or surface roughness is rated fair or worse.

#### Fog Seal and Rejuvenating Seal

After applying a fog seal, the surface friction decreased immediately and dramatically by more than 50%. However, the variability of friction also decreased by more than 60%. This implies that a fog seal may improve the pavement surface uniformity, and provide more consistent surface characteristics. It took about 18 months for the surface friction to return to the original level. The effectiveness of a fog seal varied with the surface characteristics of existing pavement to a large extent.

After applying a rejuvenating seal, the surface friction experienced a reduction by more than 40% and then increased and peaked in 30 days. Sand blotters resulted in a friction increase by 8 points and became ineffective after 1 or 2 days. The rejuvenating agent on the pavement surface could dry out in about 1 month. The pavement surface friction was unable to return to its original level after the application of a rejuvenating seal. The friction dropped by more than 18% in the passing lane and 35% in the driving lane after 24 months of application.

### Microsurfacing

The freshly placed microsurfacing could produce sufficient surface friction between 28 and 57 when opening to traffic. The surface friction of microsurfacing increased significantly in the first six months and peaked after 12 months of service. The microsurfacing surfaces became stable and produced true friction numbers between 40 and 60 after 12 months of service. After 12 months of service, the surface friction tended to decrease continuously over time. However, no friction numbers less than 30 were observed after a service period up to 42 months. The MPD values in the test sections varied between 0.66 mm and 0.94 mm.

The smoothness improvement from microsurfacing depended on the smoothness of existing pavement. The rougher the existing pavement surface the greater the smoothness improvement. However, the improvement of smoothness was limited. The two main distress modes observed in the test sections are delamination and reflective cracking.

Delamination commonly occurred at the interface between the microsurfacing and old surface. Care should be exercised when microsurfacing is applied to high traffic volume roads, particularly urban roads. Noise differences between microsurfacing and 4.75-mm HMA overlay were not perceptible on the roadside and in the vehicle.

### Ultrathin Bonded Wearing Course (UBWC)

The friction numbers on the fresh UBWC surfaces varied between 48 and 59. The friction numbers in the test sections tended to peak after 6 months of service or less, about 6 months earlier than conventional HMA mixes. UBWC has the potential to provide durable friction performance. UBWC provided coarse pavement surfaces. The measured MPD varied between 0.95 mm and 0.99 mm, much greater than that for conventional 9.5-mm HMA mixes. Significant friction decrease over time was also observed. The surface friction could decrease by more than 34% after 33 months in service. Noticeable polishing occurred to limestone aggregate. The use of steel slag could enhance the long-term friction performance. In order to provide satisfied long-term friction performance, it requires highly durable, highly polish-resistant aggregates.

### Thin 4.75-mm Dense-graded HMA Overlay

A fresh 4.75-mm HMA overlay may provide a friction number between 35 and 52, and then decreases quickly and dramatically over time after opening to traffic. In the test sections, the friction decreased by 25% after 6 months of service and by 36% to 48% after 12 months in service. The rate of friction decrease depends on traffic volume. After 12 to 18 months, the 4.75-mm HMA overlays tended to produce steady surfaces. On a steady 4.75-mm HMA surface, the friction number varies between 20 and 30 and was commonly around 20. The 4.75-mm HMA surfaces were very smooth. The majority of MPD measurements varied between 0.20 mm and 0.25 mm.

The 4.75-mm HMA mixes in the test sections were basically fine-graded mixes with too much fine sand and tended to produce significant fluctuation in surface friction over time. It is critical to employ an aggregate gradation to pass below the PCS to enhance the friction properties of 4.75-mm dense-graded mixes. A greater CA ratio may produce larger macrotexture and can be achieved by reducing the percent passing the PCS or increasing the percent passing the HS. Likely, a CA ratio approaching but less than 1.0 will have positive effect on the macrotexture of a 4.75-mm mix. Aggregate type affects surface friction. The use of steel slag will produce good texture properties. Measures for enhancing FAA

may improve surface friction. A greater SE indicates more coarse particles and may result in better macrotexture properties. The aggregate angularity and abrasion resistance also play an important role in producing and maintaining sound surface characteristics. In addition, it was observed that a greater binder grade could result in better surface texture.

### Profile Milling

It can be concluded that the steady-state friction number should not be less than 36 on a freshly profile milled HMA surface and should not be less than 40 on a freshly profile milled concrete surface. The surface friction on the profile milled surface varied over time. The long term friction performance of a ground surface depends on the aggregate properties and grinding texture configuration. It is the aggregate and land area that play an important role in providing durable texture. It appears that longitudinal grinding is capable of providing immediate and long term improvement to surface friction on both light and high traffic volume roads.

## Implementation Recommendations

This study provided INDOT with a comprehensive review of the friction performance of various surface treatments and materials. This knowledge will allow INDOT to better identify applications for various treatments and their expected friction life. Two faced crushed gravel was evaluated in this study, and is now being used routinely to give better performing chip seals. Also, the knowledge will allow INDOT to revise its specifications on mixes to address friction issues.

The 4.75 mm mixture performance issues identified by this study was first addressed by revising the INDOT specification on 4.75 mm mixes in August, 2009, and then two new 4.75 mm thin overlay projects were constructed on SR-227 and US-27 accordingly. The results were reported and the friction issues were further addressed by revising the specification again in early 2011. Consequently, eight contracts were constructed in 2011 using the revised specification. Noise performance was evaluated on microsurfacing projects and the results will be used for future projects.

New 4.75 mm thin overlay projects will be added into the field evaluation list friction test list in April, 2012, including SR-1, SR-32, SR-44, SR-64, US-24, US-40 and US-52. Noise performance will be evaluated on microsurfacing projects on SR-227 and US-421 in 2012. Further field testing and evaluation will be conducted in 2012 and 2013 on the pavement preservation treatments, including chip seals (SR-32, SR-341, US-150, SR-246, and SR-159). requires that the subgrade is able to function properly with additional fluid that may come through the joint.

## References

Li, S., Noureldin, S., Jiang, Y., Sun, Y. *Evaluation of Pavement Surface Friction Treatments*. Publication FHWA/IN/JTRP-2012/04. Joint Transportation Research Program, Indiana Department of Transportation and Purdue University, West Lafayette, Indiana, 2012. DOI: 10.5703/1288284314663

View the full text of this technical report here:  
<http://dx.doi.org/10.5703/1288284314645>

